Principles and Application of Range of Motion and Stretching in Companion Animals

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KEYWORDS

• Dog • Joint motion • Range of motion • Passive range of motion • Stretching
• Flexibility • Contracture

KEY POINTS

- Joint motion is a fundamental aspect of locomotion and activities of daily living.
- Joint motion may be restricted in companion animals after injury, surgery, or as a response to acute or chronic conditions.
- Range of motion and stretching exercises are commonly used in companion animal rehabilitation programs to maintain or improve the motion of musculoskeletal tissues and skin.
- Stretching exercises are a critical aspect of the management of joint contractures and myopathies.

INTRODUCTION

Optimal locomotion and activities of daily living require adequate motion of joints, muscles, tendon, fascia, and skin. The motion of these tissues can be negatively affected by injuries, surgery, and by acute and chronic conditions. Joint motion may be transiently or permanently lost. Range of motion (ROM) and stretching exercises positively affect tissue motion and may prevent future injuries from occurring. This article presents the general principles of ROM and stretching exercises, discusses the pathophysiology of problems negatively affecting tissue motion, and reviews the clinical applications of ROM and stretching exercises in companion animals.

ASSESSMENT OF JOINT MOTION

The appreciation of loss of joint motion requires the assessment of joint motion using a goniometer. Most often, clinicians focus on joint motion in a sagittal plane: flexion and

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extension, because that is the primary motion of joints. The method for measuring flexion and extension using a goniometer has been standardized and validated in dogs and cats.[1–3] In Labrador retrievers, for example, passive joint flexion and extension (ROM) is 32° to 196° (total of 164°) in the carpus, 36° to 165° (129°) in the elbow, 57° to 165° (108°) in the shoulder, 39° to 164° (125°) in the tarsus, 42° to 162° (120°) in the stifle, and 50° to 162° (112°) in the hip joint. Cats have a passive joint flexion and extension (ROM) of 22° to 198° (total of 176°) in the carpus, 22° to 163° (141°) in the elbow, 32° to 163° (131°) in the shoulder, 21° to 167° (146°) in the tarsus, 24° to 164° (140°) in the stifle, and 33° to 164° (131°) in the hip joint. There are some differences in joint motion among dog breeds. For example, compared with Labrador retrievers, German shepherds dog have differences in passive joint flexion and extension for the elbow, shoulder, tarsus, stifle, and hip (ie, all joints except the carpus).[3] German shepherd dogs' joints flex more (∼10°) and extend less (∼10°) than those of Labrador retrievers but overall their joints have the same ROM. The difference between Labrador retrievers and German shepherds dog is associated with Labradors being more upright than Shepherds when they stand and walk. It is not clear whether the Shepherds' gait is the consequence of their joint motion or whether the joint motion is the consequence of their gait. The gaits of Labrador retrievers and Rottweilers trotting on a treadmill were compared. Minor differences (<9°) in carpal, elbow, tarsal, and stifle motion were identified.[4] Obesity has been shown to alter gait. In a study comparing the trot of lean and obese mixed breed dogs, stance phase ROM was greater in obese dogs than in lean dogs in the shoulder (28° vs 21°), elbow (24° vs 16°), hip (27° vs 23°), and tarsal (39° vs 28°) joints.[5] Swing phase ROM was greater in obese dogs than in lean dogs in the elbow (61° vs 54°) and hip (34° vs 30°) joints. Other dog breeds also can have idiosyncratic joint motion that is the result of anatomic issues. For example, greyhounds seem to have less tarsal flexion than Labrador retrievers. The motion of joints is influenced by muscle mass, particularly when muscles of different limb segments can interfere with joint flexion. For example, dogs with muscular pelvic limbs seem to have less stifle flexion than dogs with slender pelvic limbs, and this may also be the reason why cats seem to be able to flex most joints more than dogs despite having similar extension. Joint motion is also influenced by the shape of limbs. For example, chondrodystrophic dogs with antebrachial angular deformities often lack carpal flexion, even in the absence of radiographic signs of osteoarthritis (OA) in their carpi.[6] Although joint motion is essential to being able to use a limb, some types of joint motion are required for limb use and some are not. As a general rule, the motion that is required for limb use corresponds with the ROM used at the walk and trot, and also the gallop if galloping is part of the dog's activities. At a walk, in a kinematic analysis of Labrador retrievers, the flexion and extension (ROM) of the main limb joints were estimated to be 128° to 238° (110° of ROM) in the carpus, 91° to 146° (54°) in the elbow, 88° to 125° (36°) in the shoulder, 111° to 145° (34°) in the tarsus, 111° to 146° (35°) in the stifle, and 111° to 147° (36°) in the hip joint.[7] To go from sit to stand in the same group of dogs, the motion was 133° to 202° (70° of ROM) for the carpus, 109° to 147° (37°) in the elbow, 91° to 119° (27°) in the shoulder, 95° to 131° (35°) in the tarsus, 46° to 108° (62°) in the stifle, and 49° to 115° (66°) in the hip joint.[7] These flexion values correspond with sitting position and these extension values correspond with a standing position. Measurements of joint motion differ slightly in other studies involving kinematic analysis because of differences in methodology, particularly differences in marker placement.

It is important to put loss of joint motion in perspective because the functional consequences of loss of joint motion vary widely. A dog with a loss of passive joint motion that does not overlap the motion used at a trot is likely to show no sign of lameness.

For example, if a Labrador loses ∼40° of flexion in the stifle joint as a result of OA, the passive motion of the joint would change from ∼40° (flexion) to 160° (extension) to ∼80° and ∼160° respectively. Because the ROM at a walk is (∼110°–∼150°), walking would not be affected by that loss of motion. However, sitting straight would not be possible because it requires ∼45° of stifle flexion.

Joints also move in other planes: in the coronal plane (adduction and abduction) and in the transverse plane (internal and external rotation), along the long axis of limbs (distraction), and perpendicular to the long axis of limbs (cranial drawer). These motions are referred to as secondary or ancillary. They have less amplitude (ie, are smaller) and are harder to measure, and therefore the information documenting them is generally lacking. Ancillary joint motion is part of normal locomotion and is important in working and sporting dogs. Each joint has a unique set of passive and active ancillary motions. The carpus has approximately 19° of motion in the coronal plane (varus to valgus) in Labradors retrievers.[1] The carpus also has rotational and translational motion, particularly when flexed. The elbow has ∼45° of external rotation (supination). The shoulder is a loose joint that has a high degree of abduction (measured at 33° in a group of dogs).[8] The shoulder also has internal and external rotation, adduction, and it can be distracted, creating cavitation in the joint.[9] The tarsus has a small amount of torsional motion. The stifle has extensive rotational motion (particularly internal rotation), which has been poorly described. The stifle may have some cranial drawer (in the absence of cranial cruciate ligament injury), particularly in skeletally immature dogs. The hip has a large amount of abduction, adduction, and external rotation, which are also poorly documented. In general terms, the loss of ancillary joint motion is less detrimental to limb use than the loss of flexion or extension. For example, stifle internal rotation is eliminated when extracapsular stabilization of the stifle joint is performed in cruciate-deficient dogs and elbow supination is severely restricted in dogs that undergo total elbow replacement.

The gait of patients undergoing these surgeries is altered as a result of loss of ancillary joint motion but they can bear weight appropriately, provided that the joints are stable and pain free. Restriction of ancillary joint motion places abnormal stress on bone-implant interfaces and on adjacent joints but the consequences of abnormal joint motion on adjacent joints are poorly described and may not be particularly severe. The clearest example of disorders of the adjacent joint induced by abnormal joint motion is probably the development of bicipital tenosynovitis as a consequence of loss of elbow flexion secondary to elbow OA. Tenosynovitis could be caused by overuse of the biceps brachii muscle.[10] Surgical procedures that alter joint motion may be best suited for dogs in which functional expectations are more limited (ie, in pet dogs rather than working dogs).

GENERAL PRINCIPLES OF RANGE OF MOTION AND STRETCHING EXERCISES

ROM is influenced by the shape of joints, the joint capsule, ligaments, and periarticular tendons and muscles. ROM is related to flexibility and is affected by activity, body condition, and joint health. ROM exercises are exercises that yield flexion and extension in specific joints. Passive ROM is the motion of joints that is the result of the manipulation of limbs or spine by a caregiver. In the past, clinicians avoided moving joints in the early postoperative period after surgical repair of a fracture, luxation, or joint injury but early mobilization is clearly beneficial and leads to an enhanced recovery.[11] Passive ROM promotes cartilage nutrition, decreases adhesion between tissue planes, decreases edema, and provides pain relief through a gate control mechanism. It improves joint motion and can positively affect tissue healing.[11] Passive ROM is now used extensively in the early postoperative period, until active motion returns, and it is used in chronic conditions. Passive ROM involves gentle, repetitive motion of the joint in its midrange (ie, away from full flexion and extension). In the past, passive ROM in veterinary medicine was limited to home instruction and to activities such as bicycling the limb. The principles and specific techniques of passive ROM are now delivered in a specific manner including the direction of movement, the amount of force or stress applied, the number of repetitions, and the frequency of treatment. To help determine the cause of articular, muscle, or connective tissue restrictions in motion, the examiner assesses the end feel. The end feel is the sensation imparted to the examiner's hands at the end of the ROM of the tissue being examined.[12] The normal end feel for most joints is imparted by the joint capsule and is a reflection of the elasticity of that capsule. Normal and abnormal end feels are described in **Table 1**. If passive ROM is performed too aggressively, it may result in pain, reflex inhibition, tissue damage, delayed use of the limb, and fibrosis of the periarticular tissues. The patient should not experience more than minimal pain during passive ROM. Maximal pain-free passive ROM is performed to stress the tissues but keep them within a physiologic limit. Adequate knowledge of the tissue strength postoperatively or in chronic conditions is a prerequisite to safely performing passive ROM.

When performing passive ROM, the dog should be as comfortable as possible, usually on a comfortable surface in lateral recumbency. Passive ROM may also be performed in a standing position or other functional positions such as lying over a ball, wheelbarrowing, or dancing. In any position, it is essential to maintain comfort of the animal and a stress-free position of affected joints. Individual joints are gently flexed and extended (or abducted/adducted, rotated, depending on the motion desired) through their comfortable ROM. The limb proximal to the joint is stabilized, and the limb below the affected joint is grasped and gently moved. The closer the hands are placed to the joint, the lower the forces that are applied to the joint. Over the course of several seconds, a joint is slowly flexed and extended until the first indication of discomfort, such as tensing the limb, turning the head in recognition, or trying to gently push away is noted. The end of the motion is commonly held for 1 to 2 seconds. The patient should never vocalize in pain or attempt to bite. This movement is

Table 1
Classification of joint end feels

Type of End Feel	Definition	Causes	Examples
Capsular	Slight elasticity, rubbery feel	Joint capsule elasticity	Normal tarsal flexion and extension
Firm capsular	Decreased elasticity compared with normal	Periarticular fibrosis	Loss of stifle extension after cranial cruciate ligament rupture
Soft tissue approximation	Soft tissues limiting motion	Normal when muscle bodies contact each other to stop joint motion	Normal stifle flexion
Springy	Increased spring or bounce	Joint mouse	Meniscal tear
Hard	Abrupt bony stop	Bony overgrowth, mature contracture	Mature quadriceps contracture
Empty	End of ROM cannot be reached	Pain	Intra-articular fracture

repeated for 10 to 20 repetitions, depending on the animal's reaction to the motion, 3 to 6 times daily. Flexion may be repeated as many times as indicated before performing extension passive ROM, or flexion and extension may be alternated. It is also common to only work in 1 direction, based on joint limitations. For example, it is common to only perform extension passive ROM (but not flexion) after extracapsular stabilization of a cruciate-deficient stifle or after a femoral head ostectomy.

Active ROM is the voluntary motion of joints during activities. Active ROM may be assisted or unassisted. Assistance may be provided by a sling, exercise band, brace, or other device or may be provided by decreasing the forces traveling through joints when exercising in water.[13] Active ROM occurs during all exercises. Active ROM can be used to stretch joints. Therapeutic exercises are often designed to promote (or avoid) specific joint positions.

Stretching is a form of exercise in which a muscle or muscle group is maximally elongated. Stretching is often combined with passive ROM exercises when joints have stiffness and decreased ROM or when muscles or tendons are tight. Stretching is typically performed after or as a continuation of passive ROM. The joint might be taken through its passive ROM and then held at the end point; the exercise then becomes a stretch. Stretching can be static, dynamic, or ballistic. Static stretching is the sustained elongation of muscle fibers for a brief period of time, generally greater than 10 seconds and less than 1 minute. As in performing passive ROM, the limb proximal to the joint is stabilized, and the limb below the affected joint is grasped and gently moved in the desired direction. Over the course of several seconds, a joint is slowly moved until there is the first indication of discomfort, such as tensing the limb, turning the head in recognition, or trying to gently push away. The stretch is held for 20 to 30 seconds as tolerated, and repeated 5 to 10 times. This may be done from 1 to 5 times daily, based on the need and diagnosis. A skeletally immature dog with a distal femoral physeal fracture may need passive ROM and stretching performed 5 times daily to prevent quadriceps contracture. An older arthritic dog lacking elbow extension may only have passive ROM and stretching performed once daily. Static stretching can be sustained over longer periods of time by use of a splint or brace (**Fig. 1**). Dynamic stretching is stretching performed during an activity. Ballistic stretching is a rapidly bouncing stretch. Ballistic stretching is generally not used in companion animals because animals might find it disturbing.

Fig. 1. A cat was rescued and had a lack of carpal extension (*left*). The presence of radial nerve palsy was suspected but an electromyogram indicated that the radial nerve and other nerves were normal. The cat was treated by incorporating a dynamic hinged finger brace (PIP [proximal interphalangeal] Extension Dynasplint system) into a custom splint (*right*).

Stretching is often performed in healthy and athletic dogs as a strategy that could potentially decrease the likelihood of orthopedic injury. After a dog has appropriately warmed up, specific stretches geared toward the type of activity that are planned, or that address preexisting tightness or problem areas in the dog, may be performed. Common areas for stretching include the hips, shoulders, neck, and back muscles. If a dog has sustained an injury that has resulted in residual tightness, such as in an Achilles tendon rupture, stretching of the tight area may reduce the incidence of recurrence, but strengthening exercises combined with stretching provide the best long-term protection against reinjury. To stretch a muscle, it should be placed in a position that produces a slight pull on the muscle but not to the point of pain. With a static stretch, the position in which a slight stretch is felt should be held for 15 to 30 seconds, and each stretch should be repeated 4 to 10 times on each side of the body. The stretch position should not cause pain or take the joint past the normal ROM. The American College of Sports Medicine guidelines are to stretch more than 2 days per week. If the patient has lost some joint motion or feels stiff, ROM or stretching activities should be done daily. However, it is unclear whether stretching has a protective effect with regard to orthopedic injuries during sporting activities in dogs or people and whether it improves performance.[14] Stretching that is too vigorous or performed before warming up can cause injury.

Stretching is also performed in patients that are lacking joint motion as a result of injury or surgery, or in patients with chronic conditions (OA, contractures). As mentioned earlier, not all loss of joint motion has a clinical impact. Stretching is based on the anticipated progression and the clinical impact of loss of joint motion rather than the raw number of degrees lost. A loss of stifle joint flexion after a femoral fracture warrants immediate attention because of the risk of quadriceps contracture. Skeletally immature dogs with distal humeral fractures similarly warrant attention because puppies are at increased risk of loss of joint motion after surgery and the elbow is at increased risk of loss of motion after surgery. With regard to the clinical impact of loss of joint motion, a loss of elbow extension of 10° has a larger clinical impact than a loss of elbow flexion of 40°. Joint motion required to trot comfortably is more clinically important than joint motion beyond the ROM used at a trot. Stretching can be done manually, using external coaptation, or using therapeutic exercises. When planning a stretching program, the clinician in charge should always select the most convenient and least costly method that is likely to succeed. Therapeutic exercises are more convenient than manual therapy but they can only be considered if an effective stretch can be created during exercise. Effective stretches require active joint motion and weight bearing. It is likely that all physical activities have a stretching role on muscles. For example, greyhounds that race have more hip extension than greyhounds that do not race.[15]

When stretching cannot be performed using exercises, coaptation is considered. Low-torque, long-duration stretching is safe and effective.[16] External coaptation can be used to stretch joints that lack motion. Stretching using coaptation is most effective in distal joints (carpus [see **Figs. 1** and **7**] and tarsus) because of thin soft tissue coverage. Stretching using coaptation is possible, but more challenging, in the elbow and stifle. It is not practical for the shoulder and hip joints. A thermomoldable or malleable splint can be used. The splint is shaped so that a gentle sustained stretch is placed on the joint once the leg is wrapped. Dynamic (spring-loaded) hinges or neutral hinges combined with elastic bands are more effective and convenient methods to provide sustained stretch. With dynamic hinges, the torque placed on the joint is often adjustable. That torque is increased over time during the treatment period.

If coaptation is not possible, manual therapy is selected. Manual therapy is the most labor-intensive, and therefore expensive, stretching method. A manual stretching program usually involves 2 to 3 daily stretching sessions for a period of weeks. Whenever possible, joints should be heated for a few (eg, 5 to 10) minutes before and during stretching. A temperature increase of 3 to 4°C is optimal. Stretching heated tissue maximizes safety and effectiveness.[17] Tissue heating is achieved by use of moist heat packs for superficial joints whose depth is less than 3 cm and by use of therapeutic ultrasonography for tissue depths ranging from 3 to 5 cm. The joint torque applied during stretching is adapted to the situation. A weak surgical repair in a young patient in the immediate postoperative period requires a small amount of torque applied often (**Fig. 2**). A chronic situation in a large skeletally mature patient requires preheating and maximal torque (**Fig. 3**). The anticipated gain in joint motion that results from a stretching program is 5 to 10° per week in acute and subacute situations and 3 to 5° per week in chronic situations. Gains are generally more rapid in the early part of the program compared with the late part of the program. Stretching should ideally be taught to patients (so that they tolerate it) and taught to owners (so they perform it safely and effectively) but many patients and owners are not willing or able to perform sustained stretching programs.

Careful documentation of ROM, recorded using goniometry, is necessary to assess problems and monitor their progression and response to therapy. When assessing joint motion, the feel of the joint in full flexion and extension (the end feel) should also be assessed and recorded (see **Table 1**).[12] Firm and hard end feels indicate that the loss of motion is chronic and therefore more difficult to manage.

PATHOPHYSIOLOGY OF JOINT MOTION IN COMPANION ANIMALS

Joint motion may be decreased or increased to the point of interfering with limb use. Loss of joint motion is more common than excess in joint motion. The most common source of loss of joint motion is joint disease, particularly OA. With OA, some joints lose flexion and extension. Subjectively, the motion that is lost is motion that is not

Fig. 2. A 20-week-old English setter sustained a Salter-Harris type II distal femoral fracture that was stabilized using 4 Kirschner wires placed in cross-pin fashion. The day after surgery, the dog holds his stifle joint in extension and has no active stifle joint motion (*left*). Because of the fear of quadriceps contracture, the dog remains hospitalized in a rehabilitation service for an additional week. In the first few days, low-torque stretching of the stifle is performed hourly for a few minutes (*right*).

Fig. 3. A 4-year-old Great Dane lost stifle joint extension as a result of a cranial cruciate ligament rupture that was managed without surgery. The dog is mostly non–weight bearing. Stretching sessions, performed twice daily, include preheating the joint with therapeutic ultrasound immediately followed by vigorous stretching.

used during locomotion. For example, elbow OA seems to yield more loss of elbow flexion compared with elbow extension (Marcellin-Little, unpublished data, 2004), possibly because elbow extension is used during the walk and trot (leading dogs to stretch their arthritic elbows when they move) but flexion is not. The loss of ROM secondary to OA rarely has significant clinical consequences, even if it makes the dog's gait stiff or stilted. In a study assessing hip joint motion in Labrador retrievers with hip OA, the mean loss of hip extension was 1° per year.[18] However, some dogs in that study lost up to 40° of hip extension overall. Loss of joint motion also occurs as a result of the occurrence and surgical repair of articular or juxta-articular fractures. This loss of motion may be caused in part by OA being common (70 to 85%) after the repair of an articular fracture in dogs. Also, and more importantly, that loss of motion is caused by periarticular fibrosis, loss of motion between periarticular tissue planes, and the potential development of tethers that connect the fractured region to surrounding muscles. Patients that are skeletally immature seem more likely to lose joint motion after surgery than skeletally mature dogs. Subjectively, hinged joints (eg, elbow, tarsus) are more likely to lose joint motion after juxta-articular surgery than loose joints (eg, shoulder, hip), possibly because hinged joints are tighter and have fewer ancillary joint motions. Dogs undergoing tibial plateau leveling osteotomy (TPLO), a surgery that includes an iatrogenic juxta-articular fracture and its immediate stabilization, have minor changes in stifle joint motion. In one study, mean stifle flexion in patients after TPLO was 37° compared with 29° in controls (unoperated normal contralateral stifles) and mean extension was 155° compared with 160°.[19] Loss of ROM also occurs after joint immobilization because of enzymatic changes in the joint capsule and increase in the number of myofibrobasts on the flexor side of the joint. Joint immobilization is clearly detrimental to musculoskeletal tissues. A complete review of immobilization and remobilization is beyond the scope of this article and is available elsewhere.[20]

The most dramatic form of loss of motion is quadriceps contracture, which can develop a few days to a few weeks after the repair of a femoral fracture, particularly in skeletally immature dogs and cats. In one report describing the management of femoral fractures in 28 cats, 4 cats lost stifle joint motion after surgery (**Fig. 4**).[21] The problem was referred to in the past as fracture disease or quadriceps tie-down. These names should be considered obsolete because the problem is not always associated with a fracture and does not always involve a bridge between the femur and the quadriceps. Quadriceps contracture can develop in the absence of a femoral fracture

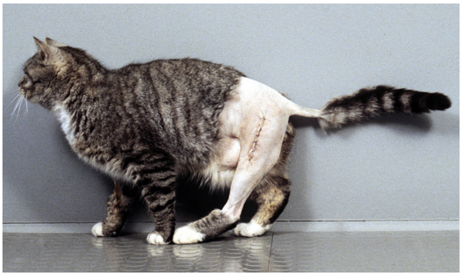


Fig. 4. A cat that underwent surgery to repair a femoral fracture is seen 14 days after surgery (*left*). The operated limb is held in excessive extension and stifle flexion is no longer possible because of a quadriceps contracture that developed during the fortnight between surgery and the reevaluation. A male pointer is presented with a quadriceps contracture (*right*). This dog had been raised with other hunting dogs and sustained no known trauma.

as a consequence of stifle joint immobilization or limb disuse. In one experimental study in dogs, pelvic limb immobilization for a 2-week period led to loss of stifle flexion but, surprisingly, less so after trauma to the quadriceps and splinting than after splinting alone, suggesting that joint immobilization is a key component of loss of stifle flexion in dogs.[22] With quadriceps contracture, the quadriceps muscle becomes fibrotic and loses all contractility. On palpation, the muscle feels as hard as bone and stifle flexion is absent. The loss of stifle motion resulting from quadriceps contracture greatly interferes with limb use. Also, the hip joint can become painful and may ultimately luxate as a result of the contracture of the rectus femoris, which is the only part of the quadriceps that originates on the pelvis.[23] The loss of ability to flex the stifle also occurs in dogs with *Neospora caninum* or *Toxoplasma gondii* infestation and can be idiopathic. A loss of ability to flex the stifles has been reported in German shepherd dogs.[24] These dogs lack the ability to flex their stifles but their quadriceps do not lose contractility. The cause of this condition is not known and efforts to help them maintain or regain stifle flexion have been unsuccessful. These dogs can have appropriate function once their cores are strengthened and once they learn to gallop (**Fig. 5**).

Loss of joint motion may also be the consequence of abnormal growth. For example, dogs with severe (grade 4) patellar luxations may have such medial displacement of the patella (and quadriceps femoris) that the quadriceps is no longer


Fig. 5. A German shepherd dog lacks stifle flexion and keeps both pelvic limbs in a hyperextended position when sitting (*left*). With time, the dog can be taught to walk and run despite the lack of stifle flexion (*right*).

functioning like an extensor muscle of the stifle joint. As a consequence, the quadriceps is not stretched during stifle joint flexion and the stifle cannot be effectively extended. Within a few months, 50° or 60° of extension may be lost (Fig. 6). Goniometry, performed under sedation, is necessary to assess joint motion in the pelvic limbs of dogs with patellar luxation. Despite being non–weight bearing on the affected limb, some dogs with patellar luxation do not experience loss of stifle joint motion. A transient or permanent loss of carpal extension has been seen in growing dogs, particularly large-breed hunting dogs. That lack of carpal extension could be secondary to bone growth that is faster than the increase in length of the antebrachial flexor muscles (Fig. 7).

Loss of joint motion may be linked to neuromuscular disease or to generalized or focal myopathies. Neuromuscular diseases are often associated with abnormal muscle function, including weakness or myalgia.[25] Canine myopathies may be inflammatory, necrotizing, dystrophic, metabolic, or congenital myopathies, and a full description is beyond the scope of this article.[25–27] A dog with generalized myoclonus resulting from distemper was successfully managed by injecting botulinum toxins in the most affected muscles.[28] Focal myopathies in dogs are sometimes reported.[29] Classic syndromes include the gracilis or semitendinosus myopathy[30] often seen in German shepherd dogs and the fibrotic myopathy of the infraspinatus,[10,31–34] often seen in hunting dogs. Isolated canine myopathies have been sporadically reported in other muscles, including the supraspinatus,[10] teres major,[35] brachialis (1 cat), sartorius,[36] and iliopsoas.[37] Muscles that cross 2 joints are reportedly more prone to contractures than muscles that cross a single joint.

Excessive motion may be present in joints as a result of joint laxity or loss of muscle tone, or as a consequence of the presence of an abnormal posture or weight distribution. Joint laxity is seen is growing dogs of (large) breeds that have loose connective tissue (eg, German shepherd dogs). It often affects the areas of increased tension, particularly the palmar fibrocartilage, gastrocnemius muscle tendon complex, and to a lesser extent plantar fibrocartilage. Affected dogs may be partially or fully palmigrade or plantigrade. Carpal laxity tends to improve over time. Joint laxity is also seen

Fig. 6. An 11-month-old toy poodle has bilateral grade 4 patellar luxation. The dog has a crouched stance. Stifle joint extension is limited to ∼110° rather than the anticipated ∼160°. Also, the pain response to stifle joint extension is severe. This dog would ideally have had a surgical correction of his patellar luxations earlier in life, before the loss of stifle joint extension.


Fig. 7. A 7-month-old Doberman pinscher lacks carpal extension (*left*). Like the cat in Fig. 1, the presence of radial nerve palsy was suspected but an electromyogram indicated that the radial nerve and other nerves were normal. The dog was treated using a dynamic hinged brace (Pediatric Knee Extension brace system; *right*).

when growing dogs carry excessive weight on parts of their bodies. For example, forelimb amputees that lose a leg while growing often have excessive motion of the scapula in relation to the body wall and excessive shoulder joint rotation. Also, growing dogs (of large and giant breeds) that shift weight toward their forelimbs, most often because of hip dysplasia, may develop excessive extension of the tarsus. Once the excessive extension develops, it may be permanent. Loss of muscle tone may be present in skeletally immature dogs because of disuse or immobilization. It may or may not be associated with muscle atrophy. Puppies most often develop a loss of muscle tone because of joint immobilization or because of the lack of limb use resulting from a chronically painful situation.

CLINICAL APPLICATIONS OF RANGE OF MOTION AND STRETCHING

Postoperative passive ROM should be considered in all patients but is particularly important in patients or situations in which loss of motion is anticipated, including skeletally immature dogs, after severe tissue trauma, in patients without active limb use, after trauma to the elbow or tarsus (Fig. 8), and after femoral fracture in cats and skeletally immature dogs. For these patients or situations, joint motion should be clearly documented and reevaluated often: daily if the problem progresses rapidly or weekly. Passive ROM and stretching must occur daily and can be delivered with the patient hospitalized or seen as an outpatient. Owner involvement should be maximized but owners should not bear the responsibility for something they may not be willing or able to do.

Stretching programs are necessary for patients that lack functionally important joint motion and should be implemented as soon as the lack of joint motion is identified because limb disuse and periarticular fibrosis tend to be self-sustaining. Stretching programs are more effective in the subacute period (1–3 weeks after injury or surgery) compared with the chronic period (>3 weeks after injury or surgery). A program can start once the acute inflammatory phase subsides; a week or so after injury or surgery. Stretching is most often done without sedation but, in rare situations, sedation may be necessary to stretch a patient.

The most critical stretching programs are done to avoid quadriceps contractures. They are implemented immediately after surgery in high-risk patients. Inpatient or daily outpatient programs are strongly recommended because owners may not recognize the signs of quadriceps contracture. Stretching after the repair of a distal femoral

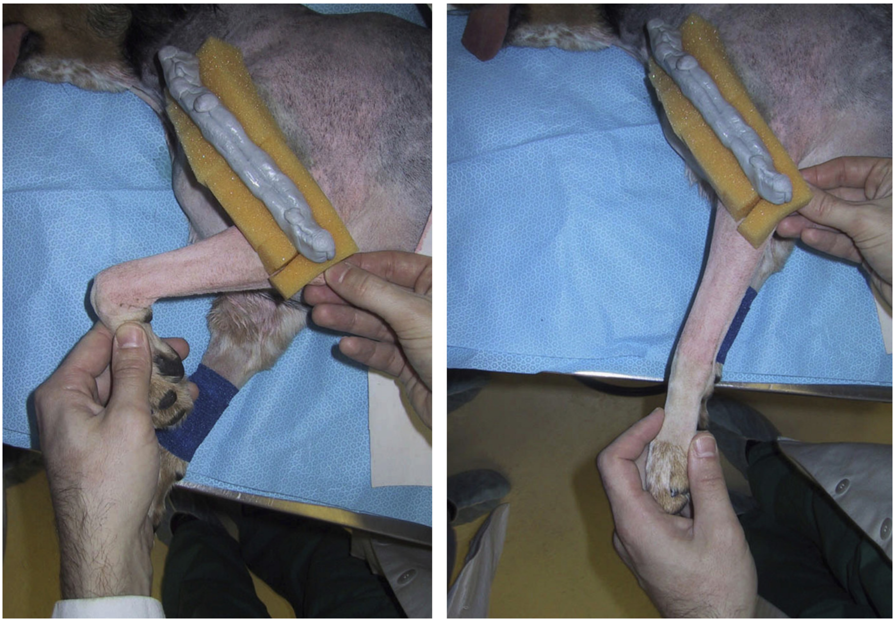

Fig. 8. A humeral fracture in a beagle has been stabilized with an external skeletal fixator with a connecting rod made of epoxy putty. Sponges were placed underneath the epoxy putty to minimize swelling and keep the skin-pin interfaces clean. Passive ROM is performed by flexing and extending the joint repeatedly with gentle pressure.

fracture in a skeletally immature dog requires little force but should take place multiple times each day. Quadriceps stretching was done successfully using a static flexion apparatus in one report involving a dog with early quadriceps contracture.[38] The stretching program subsides once stifle flexion has reached a threshold. Subjectively, once the stifle can flex to $\sim 60^{\circ}$ and once the patient is actively flexing the stifle and bearing weight on the limb, quadriceps contracture becomes unlikely.

The most common clinical situation that warrants a stretching program is a dog presenting with pelvic limb disuse as a result of a femoral head ostectomy. In these dogs, limb disuse is most often caused by the combination of severe pain during hip extension and the lack of hip extension (**Fig. 9**). Increasing hip extension is key to managing these patients. Once extension increases, the residual pain that is perceived in full extension is outside the hip ROM used at a walk and trot, and the dog can strengthen the limb through exercise. Dogs also commonly present with lack of stifle extension after extracapsular stabilization or TPLO.[39] After extracapsular stabilization, the loss of extension may be related to the location of the tibial tunnel for the stabilizing suture loop. Restriction of extension is likely if the tibial tunnel is too distal. After TPLO, a loss of extension greater than 10° is uncommon (<3% in one study) but it is associated with increased lameness and decreased response to physical rehabilitation.[39] General physical rehabilitation increases stifle flexion and extension after TPLO.[40] For patients that lack joint motion 3 weeks after surgery, a stretching program that involves heating and stretching should be considered. A stretching program should similarly be considered any time an injured patient presents with a loss of motion after surgery, particularly after any fracture repair but also with any fracture involving an open growth plate (because the patient is young and growing), involving the elbow or tarsus (because these joints seem to be most vulnerable to loss of motion), or associated with severe

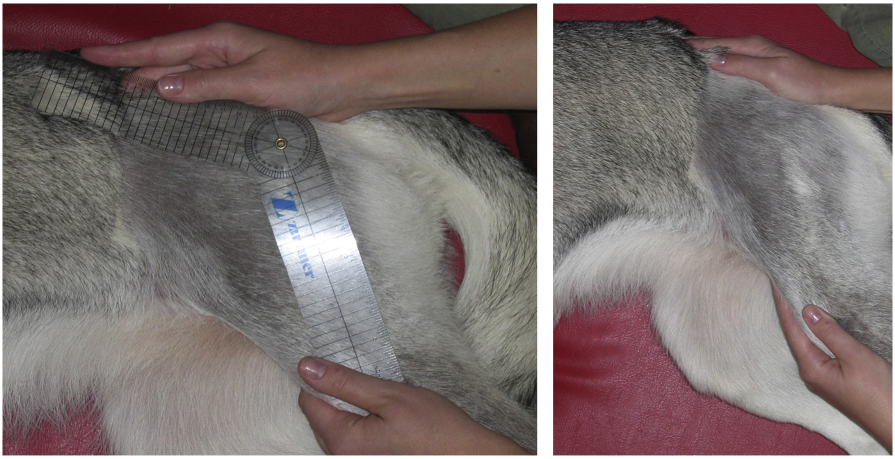

Fig. 9. A 1-year-old Siberian husky has left pelvic limb disuse after a femoral head ostectomy performed 2 months earlier. A severe pain response to hip extension combined with a 35° lack of hip extension is present at the time of initial evaluation (*left*). Therapy included heating the hip region with a moist heat pack, stretching the hip primary to gain extension (*right*), and the design of an exercise program that included limb use.

tissue trauma or infection (because more tissue trauma or infection yields more fibrosis). Patients undergoing limb lengthening often need stretching of the joint distal to the bone being lengthened. It is often possible to connect bars to the distal aspect of a circular external fixator and connect a sling made of self-adhesive bandage material to these bars to achieve safe and convenient low-torque sustained stretching.[41]

Loss of range motion is a key feature of OA. In humans, features of articular degeneration are associated with reduced knee ROM and reduced hip ROM in patients with early OA. Pain, stiffness, higher body mass index, and male gender are associated with reduced ROM as well.[42] Stretching is beneficial to some dogs and cats with chronic OA. As mentioned earlier, not all patients with OA lose joint motion and few lose enough joint motion to have clinical consequences. In a study evaluating Labrador retrievers with hip dysplasia, loss of extension was associated with an increase in clinical signs.[18] Also, a more active lifestyle was associated with less lameness in these dogs. Because exercise stretches and increases strength, it is logical to keep dogs with OA as active as tolerated. Subjectively, it seems that tighter joints with OA lose more motion than looser joints with OA. For example, large losses of elbow and tarsal flexion are common with OA. It is not known whether staying active could decrease these losses. In patients with significant loss of joint motion, stretching through exercise should be considered first. Land-based exercise and aquatic exercises are equally beneficial to ROM in humans with knee OA.[43] Manual stretching should be considered for patients with OA with severe loss of joint motion that cannot exercise. Progress is likely to be slow because of chronicity and ideally the owner should get involved to reduce the cost of care. A small pilot study in 10 dogs with OA suggested that home-based stretching programs are beneficial to patients with OA.[44] Patients with OA can also see gains in joint ROM. Increased hip flexion was present in dogs with OA in one study and an increase in ROM in the shoulder, elbow, carpus, and tarsus, was present in cats with OA in another.[18,45] Increases in joint motion are likely caused by loss of muscle mass for joint positions with soft tissue approximation end feels (see **Table 1**). Patients recovering from total joint arthroplasty may need a stretching program, because most joint replacements are done in joints with severe OA that are likely to lack joint motion. In dogs, loss of joint motion seems more likely after total knee and elbow replacement, compared with hip replacement. With a stretching program that involves manual stretching replaced over time by controlled exercises, significant gains in joint motion can be achieved.[46]

Stretching for joint health is done often in performance dogs, including dogs that race, track, perform agility, work, and do conformation. As mentioned earlier, little is known about optimal stretching parameters and the impact of stretching on injury rate and performance. It is therefore logical to follow a general approach to warm-up and cool-down exercises without being dogmatic about specific parameters. Warming up can include walking for a few minutes followed by gentle manual stretching of forelimbs and hind limbs. Stretching should be performed immediately before exercise because the effects of stretching on joint motion are short lived, lasting only 6 minutes in one study.[47] Warming up does not make muscles less stiff or longer; it only influences stretch tolerance.[48]

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